

Space Planning Software

for astronauts and spacecraft

schedules spun for tomorrows to come

Bob Kanefsky
NASA Ames Research Center
SJSU Research Foundation

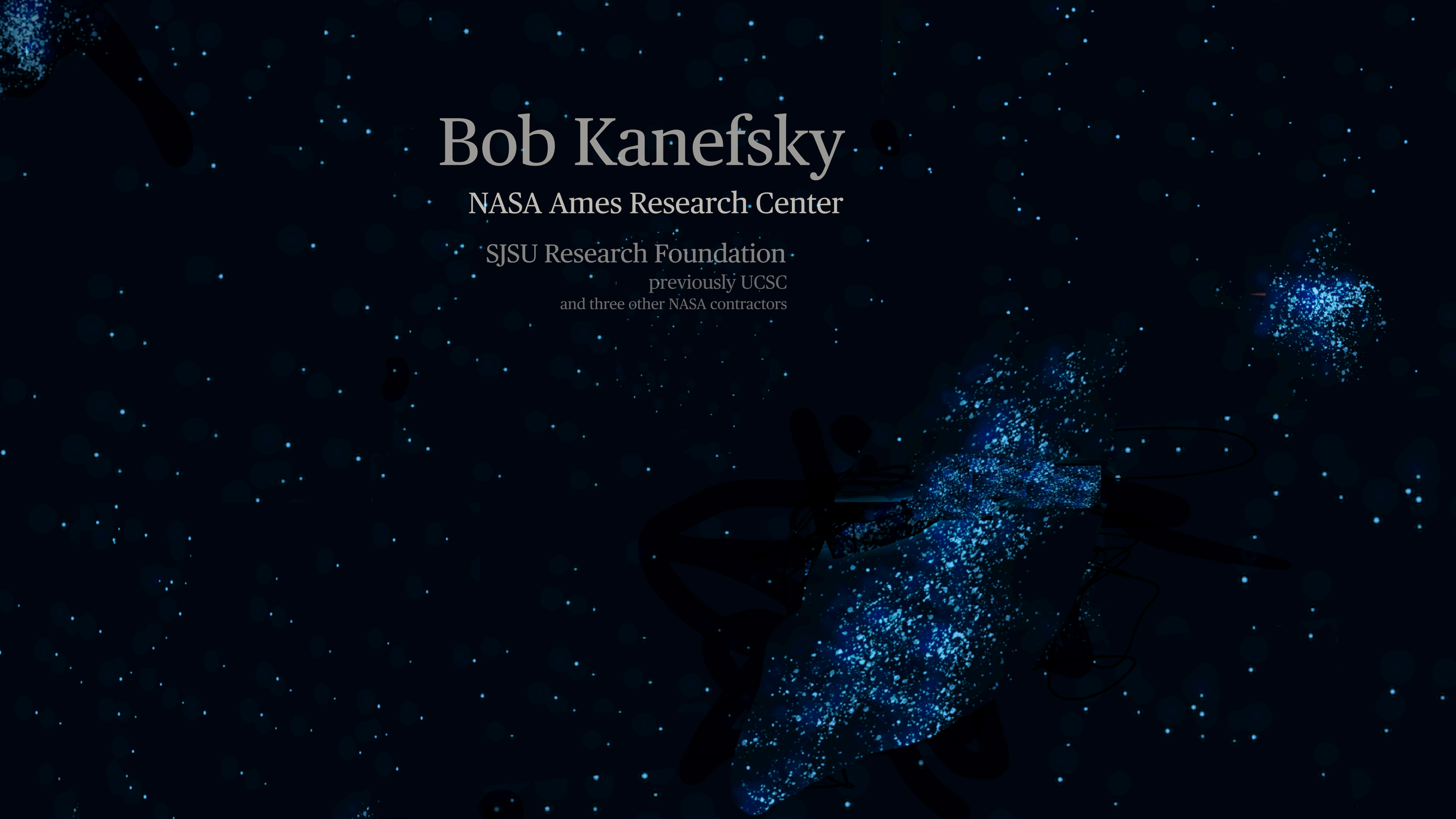
Bob Kanefsky

NASA Ames Research Center

SJSU Research Foundation

previously UCSC

and three other NASA contractors

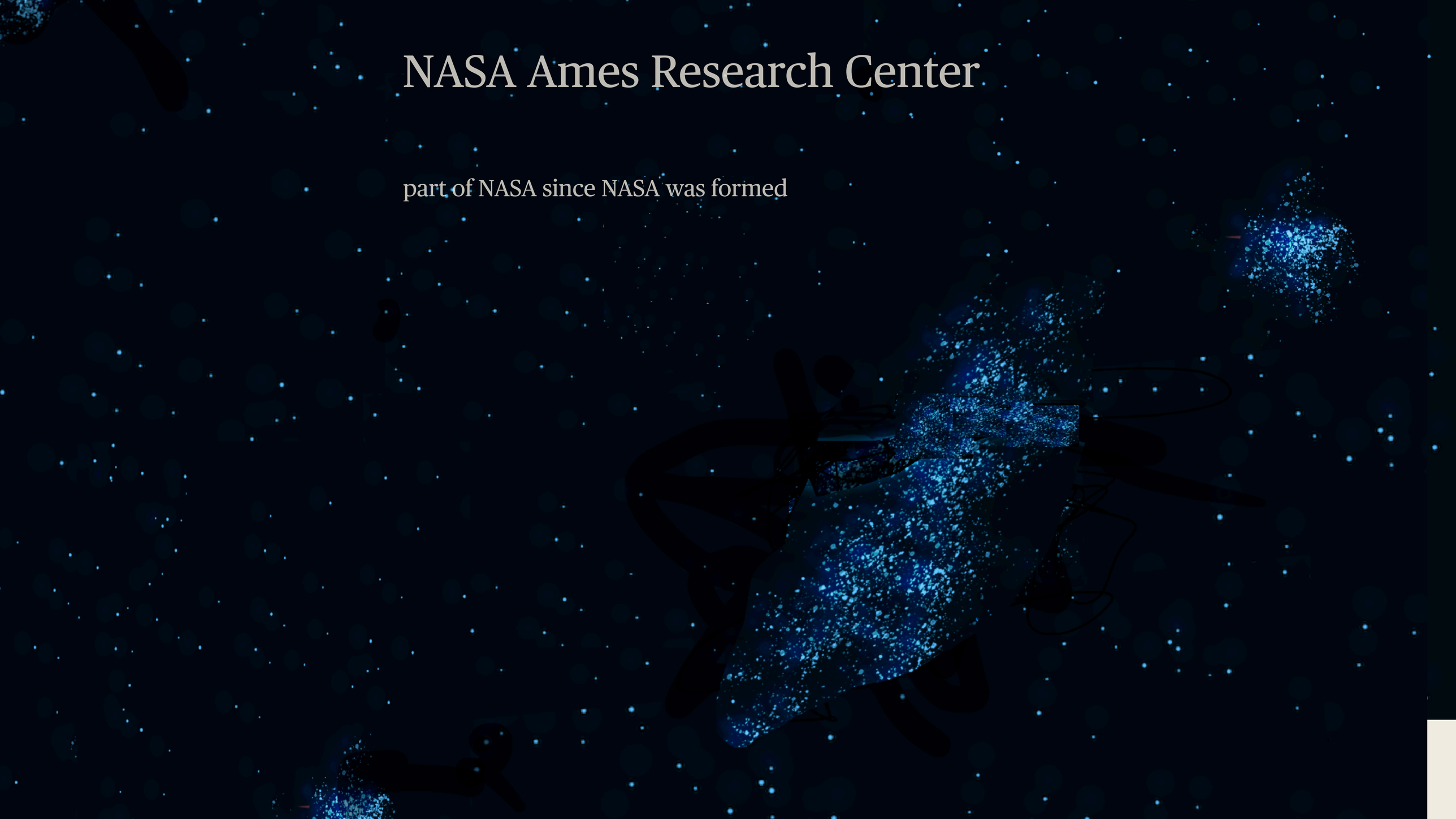


NASA Ames Research Center



NASA Ames Research Center

part of NASA since NASA was formed



NASA Ames Research Center

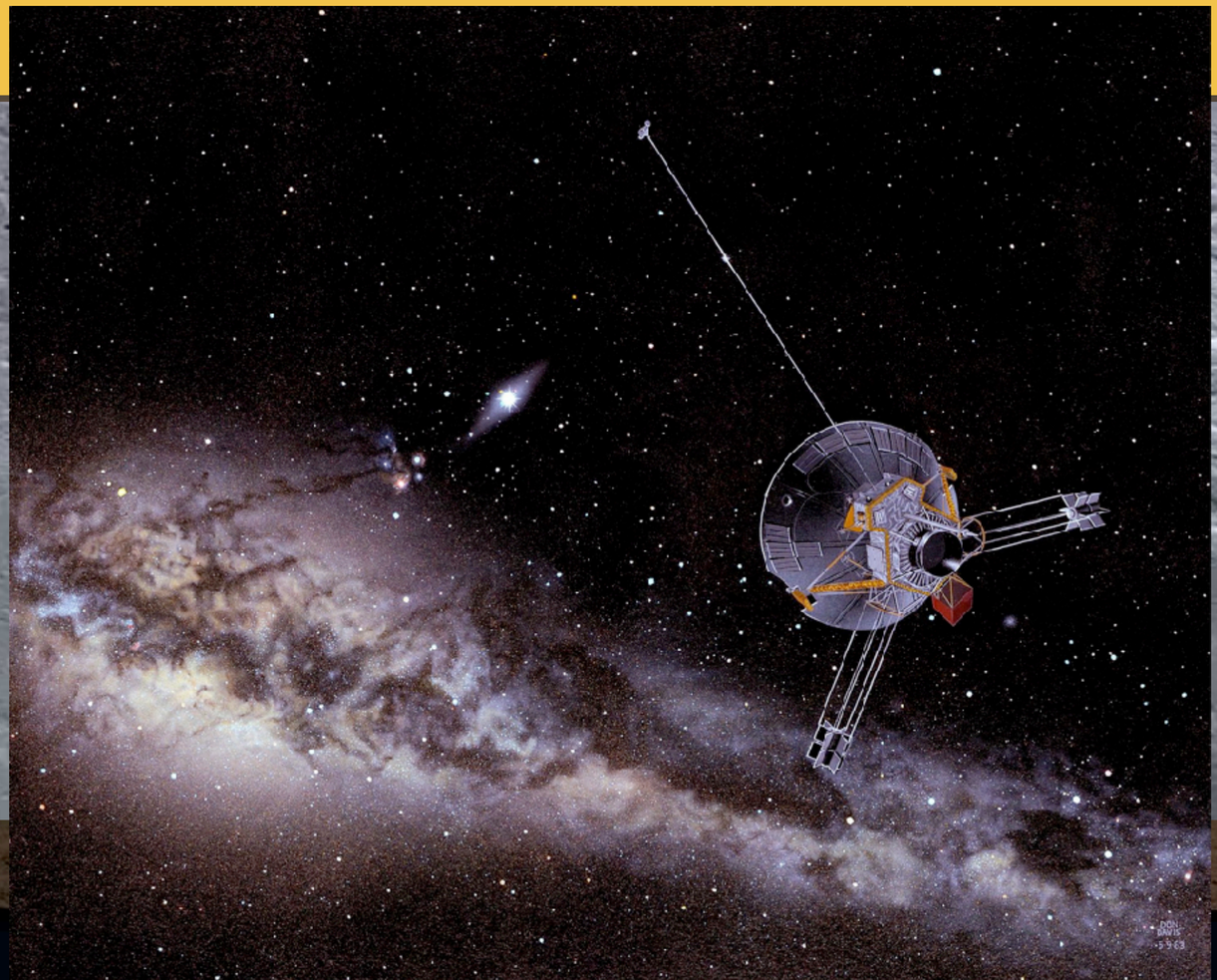
actually older than NASA, formerly part of NACA



NASA Ames Research Center

besides research, has led some cool missions

PIONEER 10







Exploration Technology Directorate



Human-Systems Integration Division



Human-Computer Interaction Group



SPIFe team



Ames Research Center



Human-Computer Interaction Group

HCI METHODS

- contextual inquiry
- participant observation
- user tests
- surveys

OTHER HCI TEAMS WORK ON

- Tools for decision-making, hazard tracking, etc.
- Human Performance Modeling
- Wearable Computing
- Human-Robot Interaction
- Planetary Operations



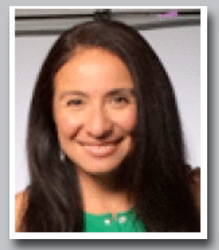
SPIFe team

ALSO remote participant observation

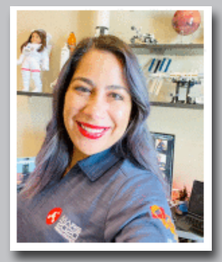
SPIFe team

Ames Research Center

Playbook
our current software



Jessica Marquez
Team Lead
Research Lead



Ivy Deliz
Technical Lead
Developer



Jimin Zheng
Designer



Bob Kanefsky
Developer



Anthony Robinson
Developer

and other past and present researchers, interns, managers

Ames Research Center

We're also part of JPL's Mars 2020 (Perseverance) mission!

COCPIT = **Playbook** adapted & integrated with other tools

GROUND DATA SYSTEM

Amy A, manager
Usha G., dev manager
Guy P., engineer
Reynaldo L-P., infrastructure

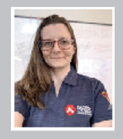
ROVER PLANNING SUBSYSTEM

Jeng Y., lead
Recaredo T., deputy

ACTIVITY PLANNING & SEQUENCING SUBSYSTEM



COCPIT









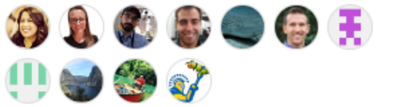


OTHER APSS TOOLS

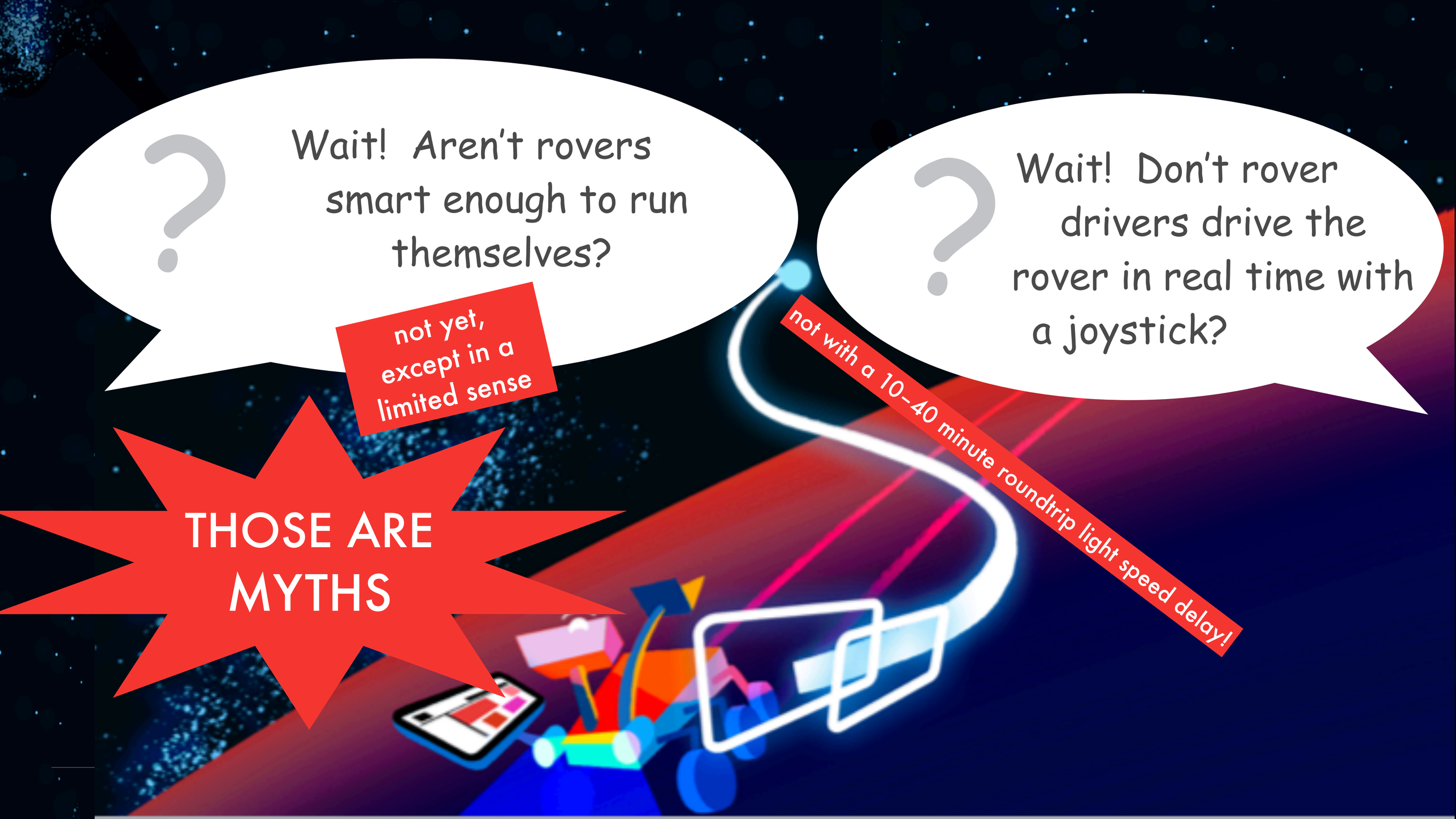
whose engineers also helped design and testing develop COCPIT

and other past engineers who have moved on

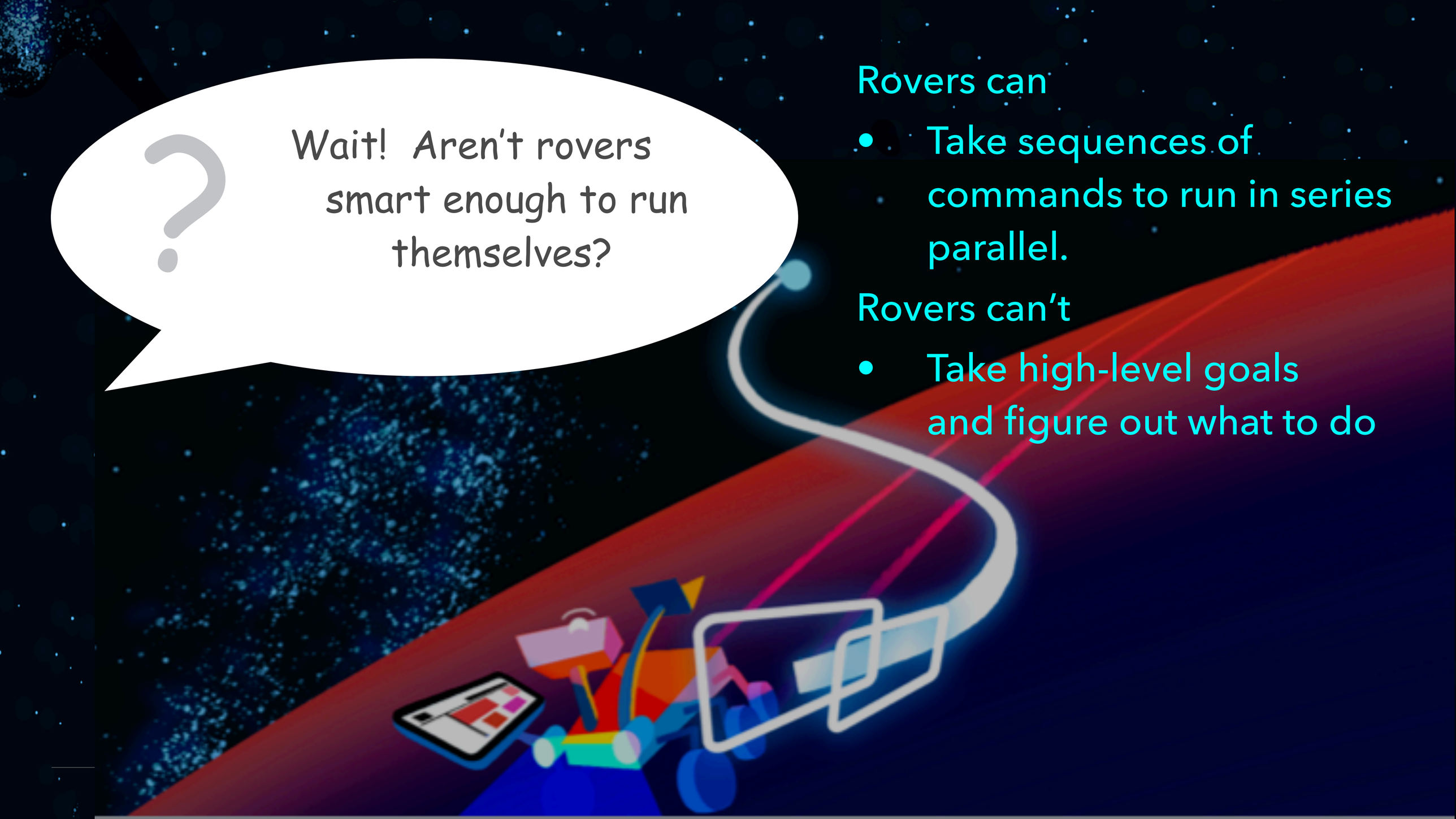
Contributors 14

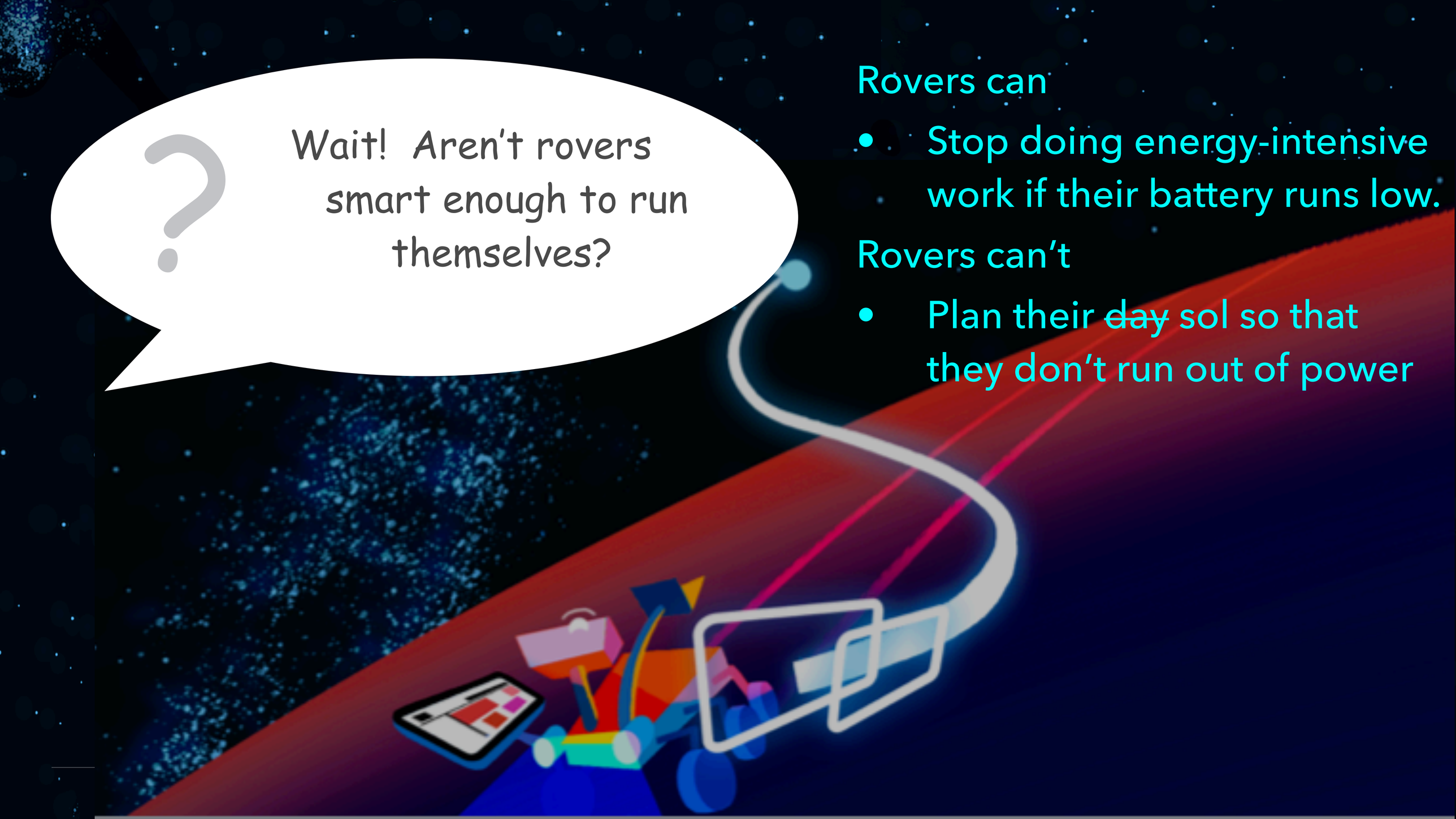


+ 3 contributors


Wait! Aren't rovers smart enough to run themselves?
not yet, except in a limited sense
Wait! Don't rover drivers drive the rover in real time with a joystick?
not with a 10-40 minute roundtrip light speed delay!
THOSE ARE MYTHS




?
Wait! Aren't rovers smart enough to run themselves?
Rovers can
• Take sequences of commands to run in series parallel.
Rovers can't
• Take high-level goals and figure out what to do



Rovers can

- Stop doing energy-intensive work if their battery runs low.

Rovers can't

- Plan their ~~day~~ sol so that they don't run out of power

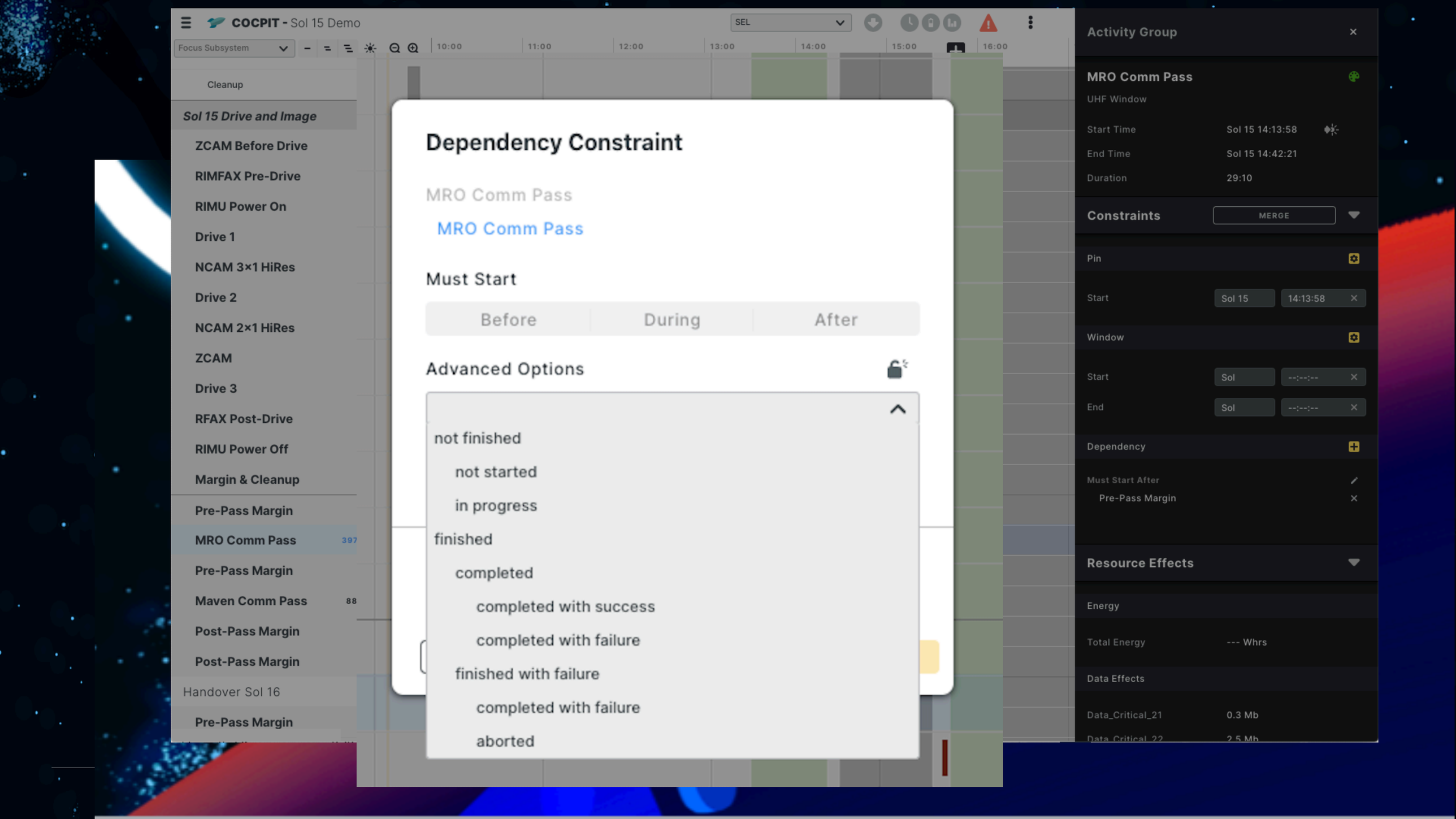

?
Wait! Aren't rovers smart enough to run themselves?
Rovers can
• Stop an activity if it's time to do an incompatible one.
• Wait for the activity to finish before starting the incompatible one.
Rovers can't
• Plan what order to do things in
As of today! An on-board planner may be operational on Perseverance soon.

IT TAKES A LARGE NUMBER OF PEOPLE – DOZENS AT A TIME FOR TWO SHIFTS (14 HOURS) – TO PLAN EACH SOL.

BUT
NOW
DOWN TO 5
HOURS A DAY THANKS
TO EASIER-TO-USE
TOOLS, INCLUDING COCPIT.






COCPIT - Sol 15 Demo
SEL
Focus Subsystem
10:00
11:00
12:00
13:00
14:00
15:00
16:00
Cleanup
Sol 15 Drive and Image
ZCAM Before Drive
RIMFAX Pre-Drive
RIMU Power On
Drive 1
NCAM 3×1 HiRes
Drive 2
NCAM 2×1 HiRes
ZCAM
Drive 3
RFAX Post-Drive
RIMU Power Off
Margin & Cleanup
Pre-Pass Margin
MRO Comm Pass 397
Pre-Pass Margin
Maven Comm Pass 88
Post-Pass Margin
Post-Pass Margin
Handover Sol 16
Pre-Pass Margin
Dependency Constraint
MRO Comm Pass
MRO Comm Pass
Must Start
Before
During
After
Advanced Options
not finished
not started
in progress
finished
completed
completed with success
completed with failure
finished with failure
completed with failure
aborted
Activity Group
MRO Comm Pass
UHF Window
Start Time
Sol 15 14:13:58
End Time
Sol 15 14:42:21
Duration
29:10
Constraints
MERGE
Pin
Start
Sol 15
14:13:58
Window
Start
Sol
End
Sol
Dependency
Must Start After
Pre-Pass Margin
Resource Effects
Energy
Total Energy
--- Whrs
Data Effects
Data_Critical_21
0.3 Mb
Data_Critical_22
2.5 Mb

Of course…



THE ROVER DOESN'T LITERALLY READ THE ACTIVITY TIMELINE (LET ALONE LOOK AT THE COCPIT UI), BUT ITS COMMANDS ARE GENERATED FROM THE PLAN.

"Ultimately the information from the COCPIT plan is translated to sequences that will be bundled and radiated to Perseverance for execution."

– Ivy Deliz et al, 2022

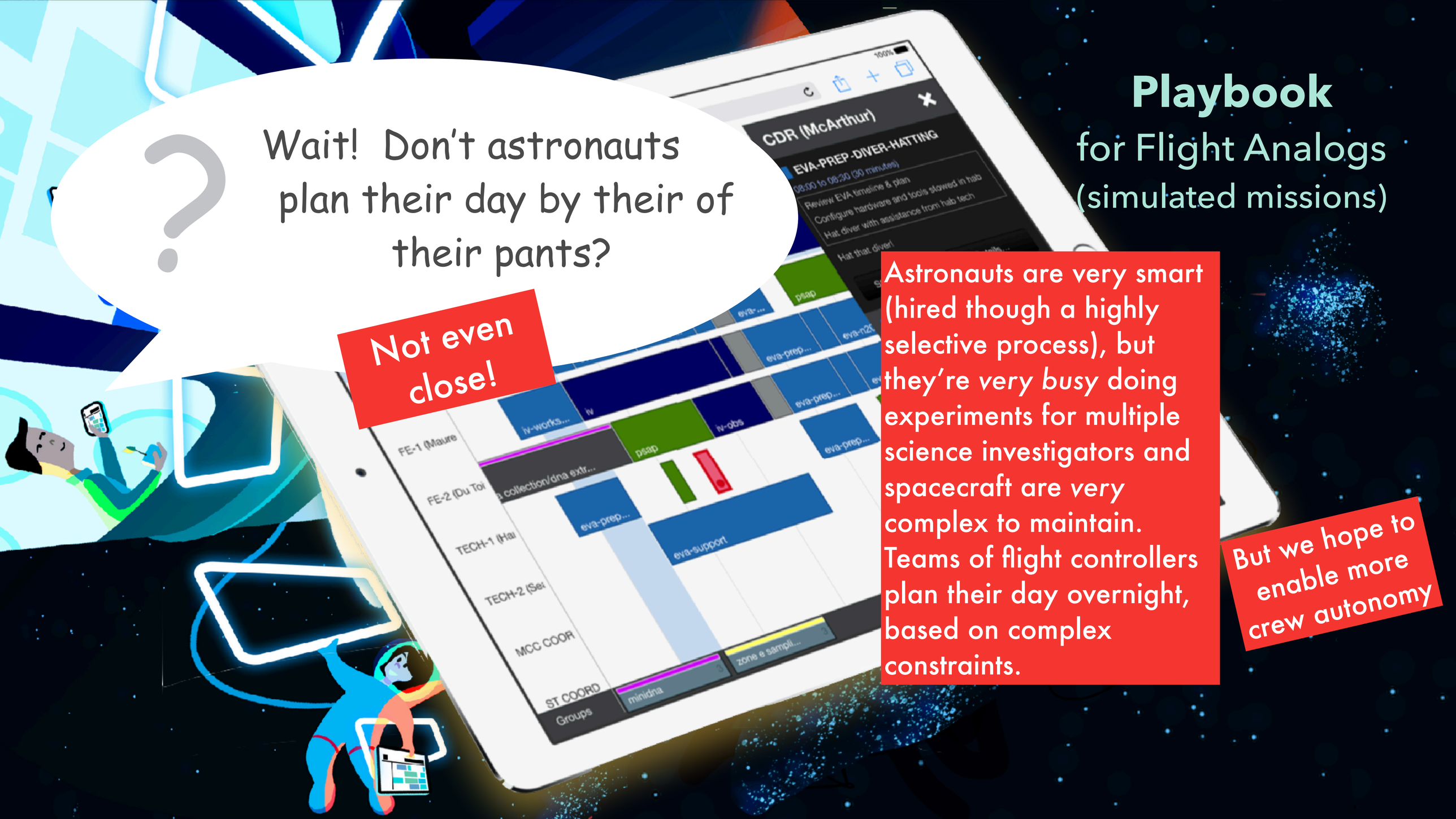
Playbook
for Flight Analogs (simulated missions)

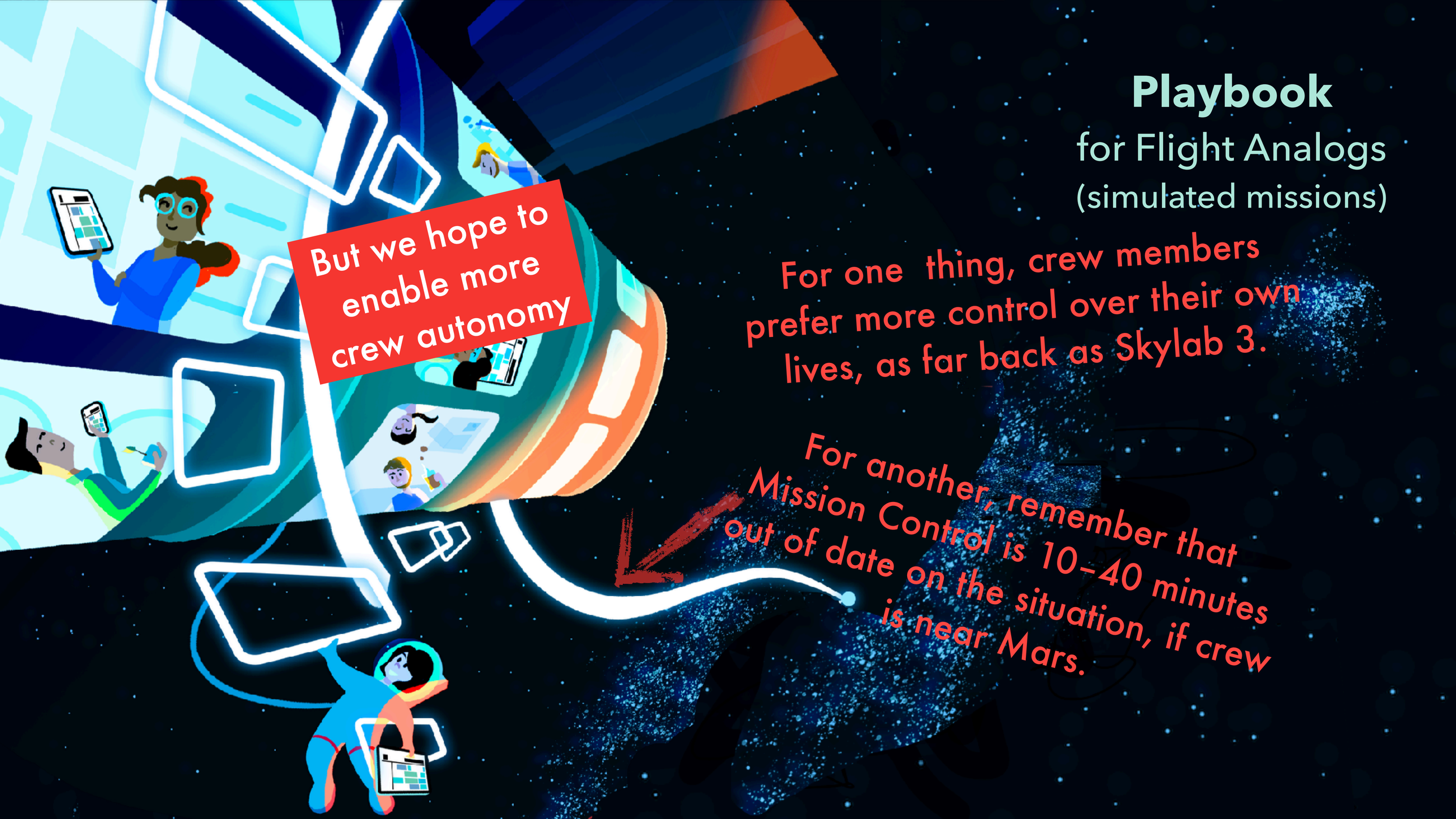
Wait! Don't astronauts plan their day by their of their pants?

Not even close!

Astronauts are very smart (hired though a highly selective process), but they're *very busy* doing experiments for multiple science investigators and spacecraft are *very* complex to maintain. Teams of flight controllers plan their day overnight, based on complex constraints.

But we hope to enable more crew autonomy



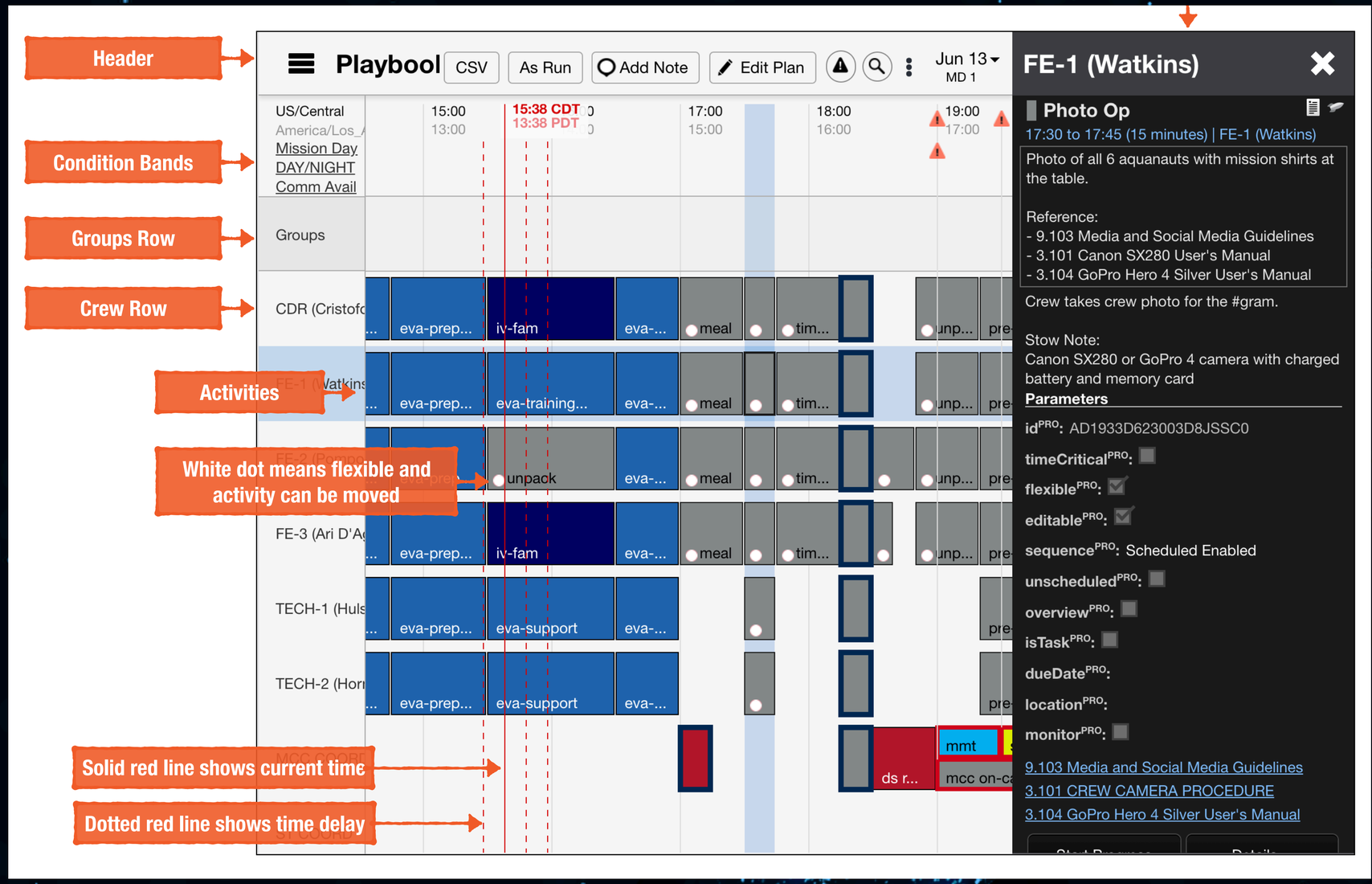


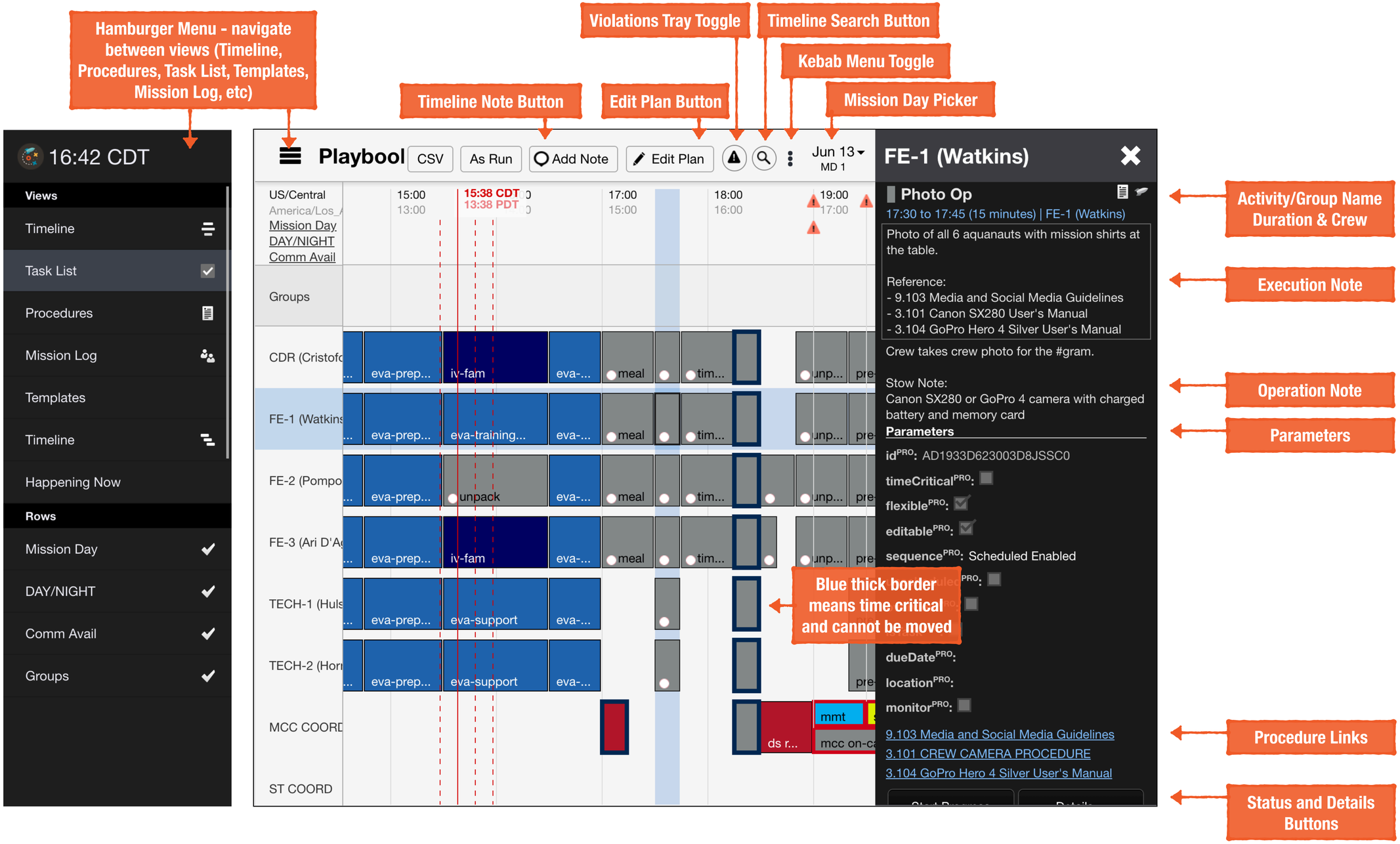
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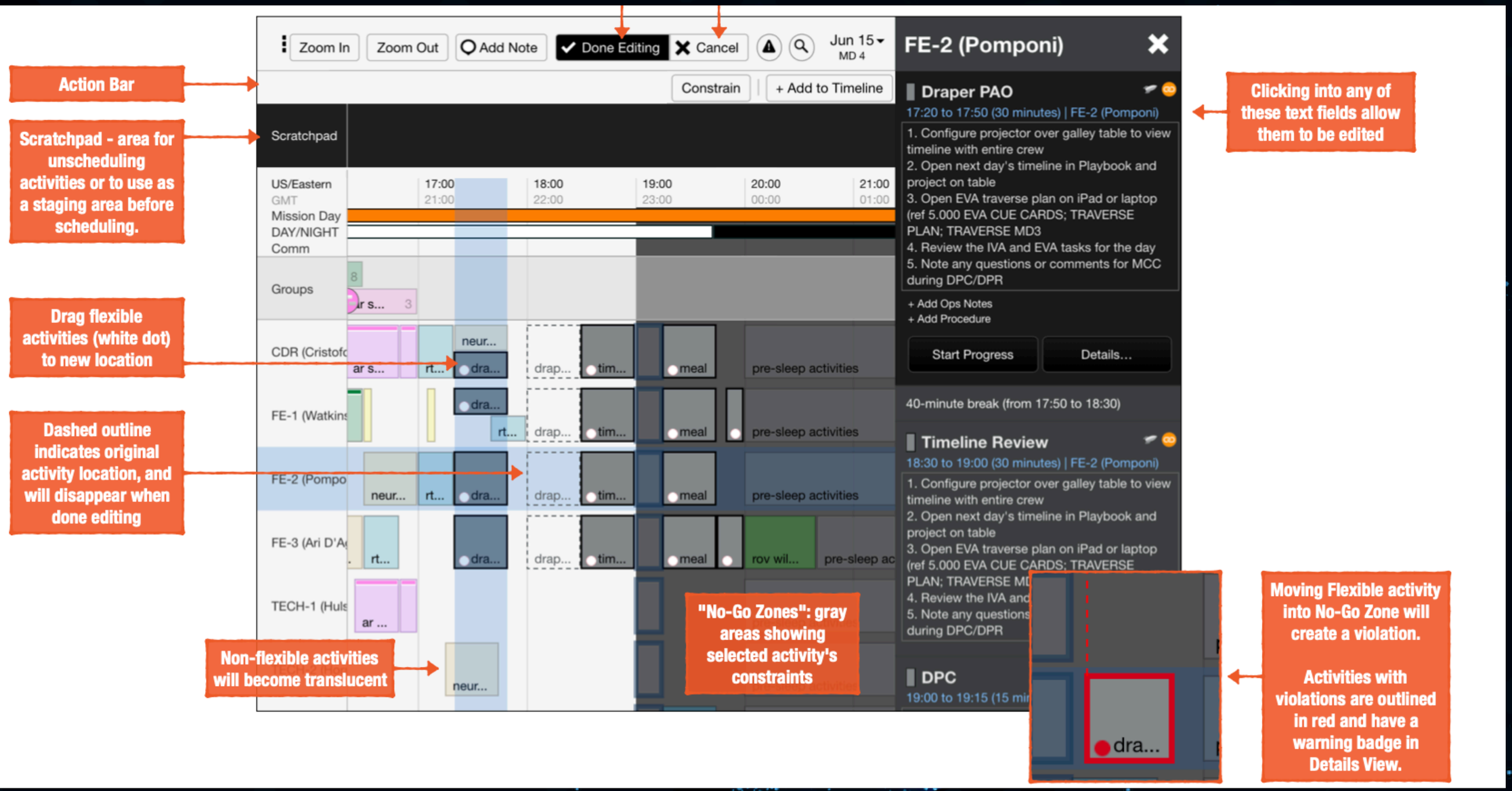
For one thing, crew members prefer more control over their own lives, as far back as Skylab 3.

For another, remember that Mission Control is 10–40 minutes out of date on the situation, if crew is near Mars.

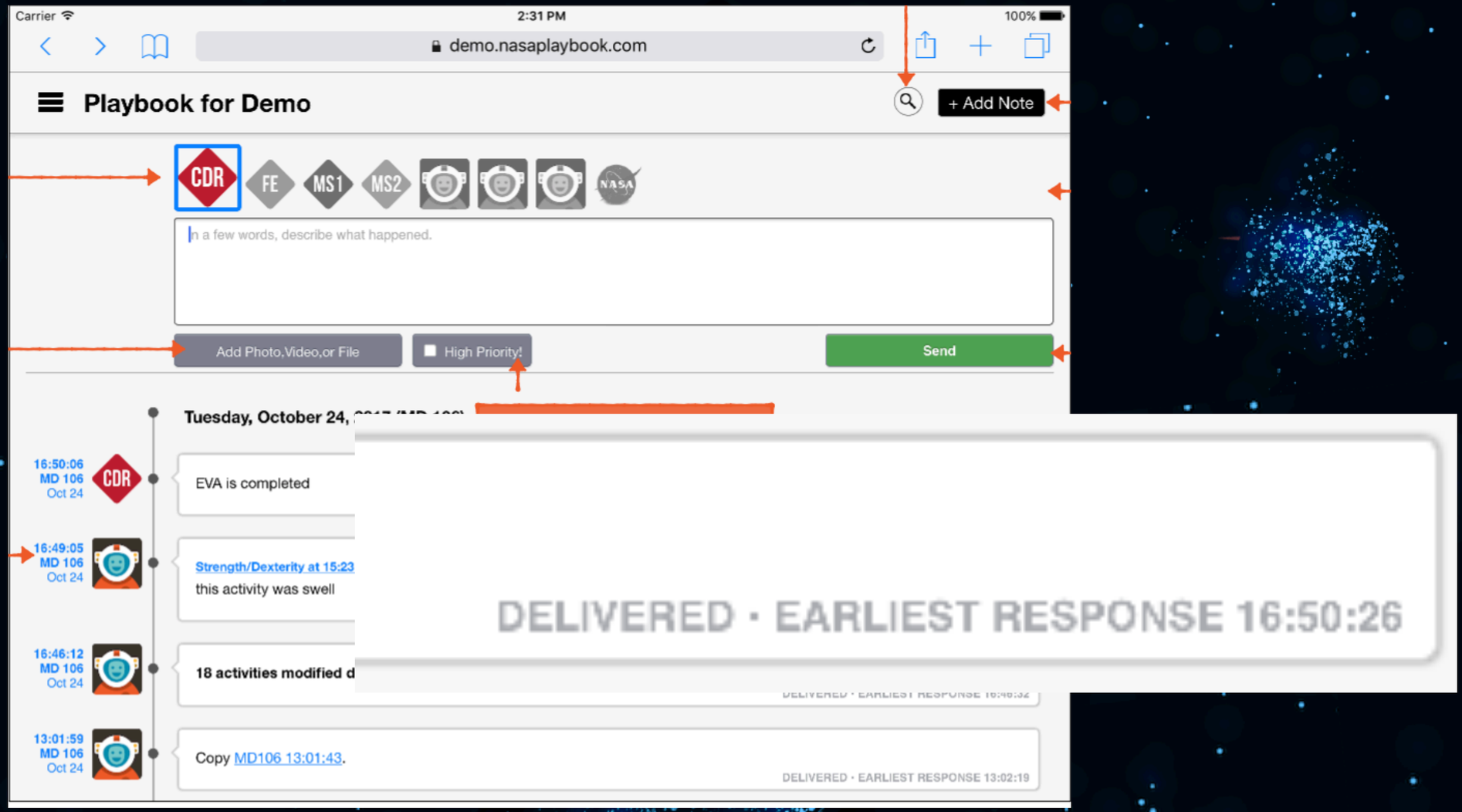

Header
Condition Bands
Groups Row
Crew Row
Activities
White dot means flexible and activity can be moved
Solid red line shows current time
Dotted red line shows time delay
Playbool
CSV
As Run
Add Note
Edit Plan
Jun 13
MD 1
US/Central
America/Los_
Mission Day
DAY/NIGHT
Comm Avail
15:00
13:00
15:38 CDT
13:38 PDT
17:00
15:00
18:00
16:00
19:00
17:00
Groups
CDR (Cristofo
FE-1 (Watkins
FE-3 (Ari D'Ag
TECH-1 (Huls
TECH-2 (Horr
MCC COORD
eva-prep...
iv-fam
eva-...
meal
tim...
unp...
eva-training...
unpack
eva-support
mmt
ds r...
mcc on-ca
FE-1 (Watkins)
Photo Op
17:30 to 17:45 (15 minutes) | FE-1 (Watkins)
Photo of all 6 aquanauts with mission shirts at the table.
Reference:
- 9.103 Media and Social Media Guidelines
- 3.101 Canon SX280 User's Manual
- 3.104 GoPro Hero 4 Silver User's Manual
Crew takes crew photo for the #gram.
Stow Note:
Canon SX280 or GoPro 4 camera with charged battery and memory card
Parameters
idPRO: AD1933D623003D8JSSC0
timeCriticalPRO:
flexiblePRO:
editablePRO:
sequencePRO: Scheduled Enabled
unscheduledPRO:
overviewPRO:
isTaskPRO:
dueDatePRO:
locationPRO:
monitorPRO:
9.103 Media and Social Media Guidelines
3.101 CREW CAMERA PROCEDURE
3.104 GoPro Hero 4 Silver User's Manual


Hamburger Menu - navigate between views (Timeline, Procedures, Task List, Templates, Mission Log, etc)
Violations Tray Toggle
Timeline Search Button
Kebab Menu Toggle
Timeline Note Button
Edit Plan Button
Mission Day Picker
16:42 CDT
Views
Timeline
Task List
Procedures
Mission Log
Templates
Timeline
Happening Now
Rows
Mission Day
DAY/NIGHT
Comm Avail
Groups
Playbool
CSV
As Run
Add Note
Edit Plan
Jun 13
MD 1
US/Central
15:00
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17:00
18:00
19:00
Mission Day
DAY/NIGHT
Comm Avail
Groups
CDR (Cristofo
FE-1 (Watkins
FE-2 (Pompo
FE-3 (Ari D'Ag
TECH-1 (Huls
TECH-2 (Hori
MCC COORD
ST COORD
eva-prep...
iv-fam
eva-training...
unpack
eva-support
meal
tim...
mmt
ds r...
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sequence PRO: Scheduled Enabled
dueDate PRO:
location PRO:
monitor PRO:
9.103 Media and Social Media Guidelines
3.101 CREW CAMERA PROCEDURE
3.104 GoPro Hero 4 Silver User's Manual
Blue thick border means time critical and cannot be moved
Activity/Group Name Duration & Crew
Execution Note
Operation Note
Parameters
Procedure Links
Status and Details Buttons

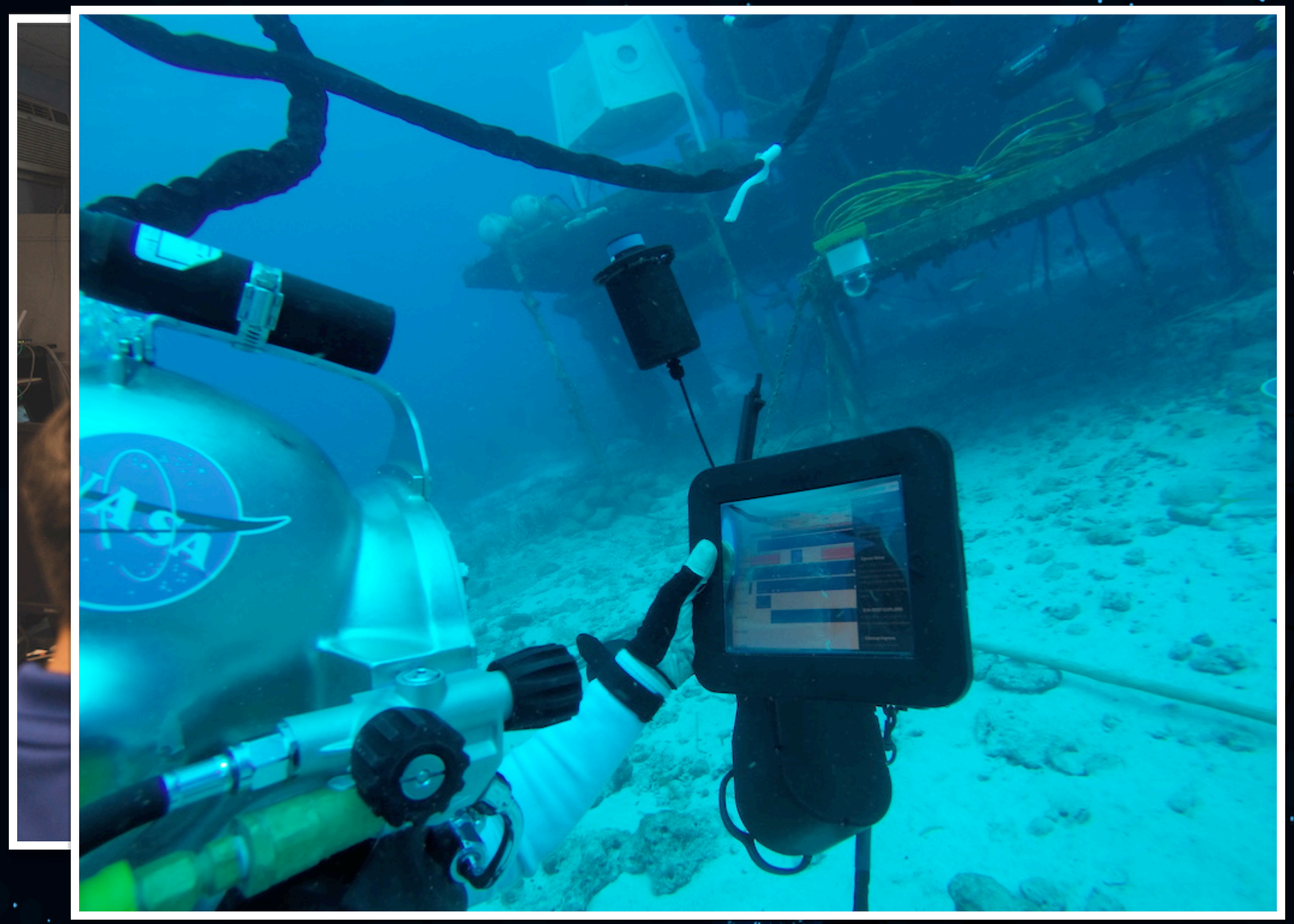
Crew Self-Scheduling UI



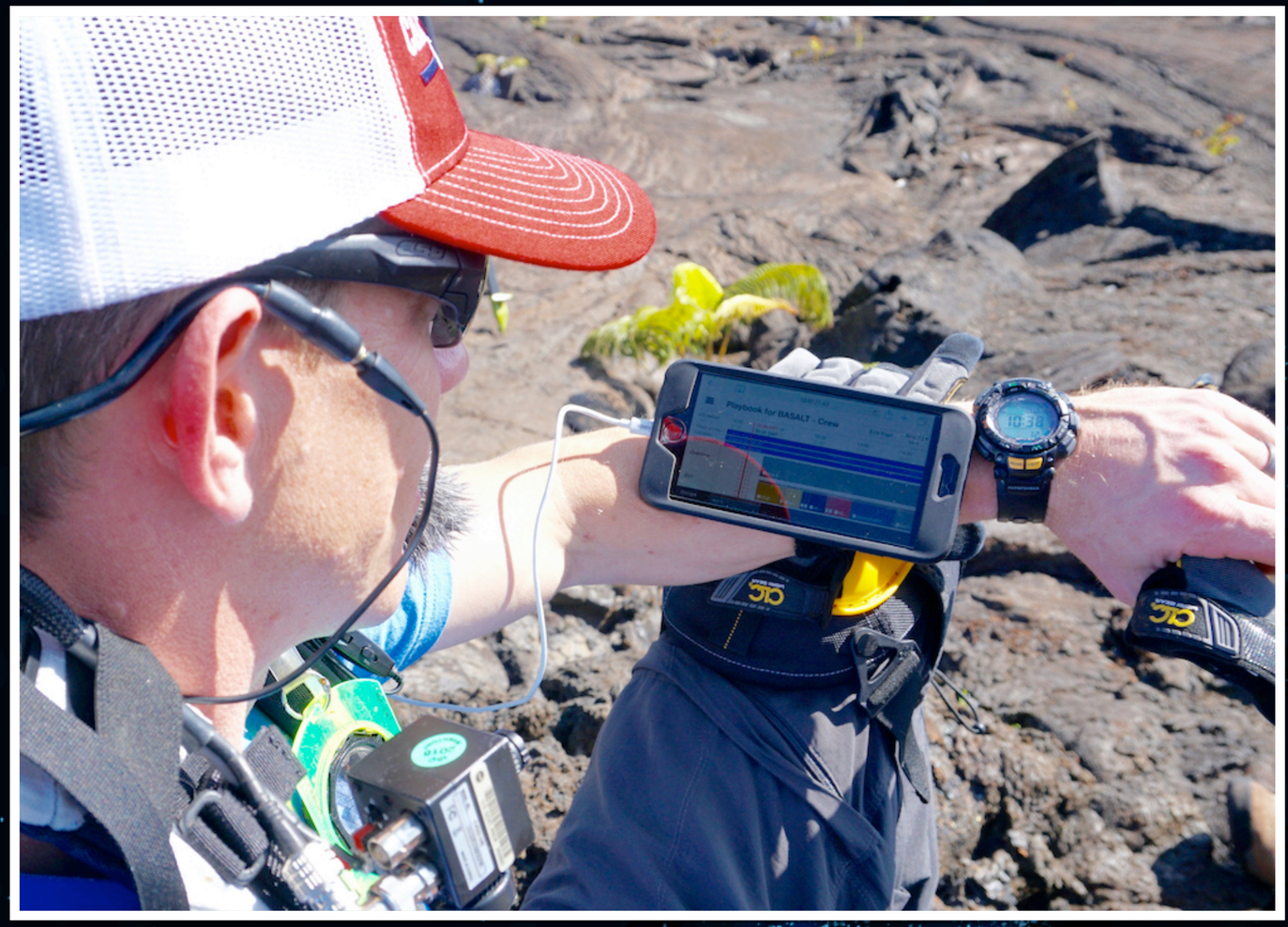
Texting in “space”: simulated light-speed delay



Playbook is used by NEEMO Mission Control and crew



Playbook was used by BASALT Mission Control and crew



Playbook was demonstrated onboard ISS



Crew Autonomous Scheduling Test